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(54) **A CONTINUOUS ELECTROFORMING PROCESS TO FORM A STRIP FOR BATTERY ELECTRODES AND A MANDREL TO BE USED IN SAID ELECTROFORMING PROCESS**

KONTINUIERLISCHES ELEKTROFORMUNGSVERFAHREN FÜR BATTERIE-STREIFENELEKTRODEN UND DORN ZUR VERWENDUNG IN DIESEM ELEKTROFORMUNGSVERFAHREN

PROCEDE D'ELECTROFORMAGE CONTINU SERVANT A FORMER UNE BANDE POUR ELECTRODES DE BATTERIE ET MANDRIN UTILISE DANS LEDIT PROCEDE D'ELECTROFORMAGE

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Description

[0001] The invention relates to a continuous electroforming process to form a strip for battery electrodes, comprising the steps of providing a mandrel having on its surface a reusable pattern subdivided into conductive and non-conductive areas; moving said mandrel through an electroforming bath to deposit a metal layer on said mandrel while it moves through the electroforming bath until the metal layer has assumed the shape of the conductive pattern and a thickness at least sufficient to provide strength for the layer to be removed from said mandrel; and separating said layer from said mandrel. The invention further relates to a mandrel to be used in the electroforming process. The present invention is concerned specifically with the continuous production of electrodes, preferentially in foil and grid form, by electroforming, and with obtaining products of specified optimal properties.

[0002] DE 44 04 817 C1 describes a process to manufacture battery grids by electroforming. However, the discontinuous process claimed there is limited to a production of individual grids on a plate-shaped cathode. Such a process is difficult to control and is not sufficiently economical. Furthermore, modern technology of battery plate production has changed over to a continuous process. It requires that the electrodes are provided in the form of an "endless" strip-shaped feed material of electrodes connected to each other. Any new process which is to provide competitive or superior productivity and product properties will have to satisfy the requirements of the continuous plate making process.

[0003] Electrodeposition processes to produce metal continuously as a strip in sheet or foil form have been known for a long time.

[0004] US 1,567,079 discloses a continuous electrolytic process of forming sheet cathodes comprising the initial formation of a single sheet cathode on a horizontally moving, vertically disposed surface in a winding direction, then parting the cathode from the moving surface in an unwinding direction without interrupting the electrodeposition, then interrupting the deposition and then continuing the deposition upon the initially formed cathode, as it is moved horizontally in a vertical plane, whereby a plurality of sheet cathodes will be formed upon the surface of the cathode initially formed.

[0005] DE 585 633 and GB 1415913 use a horizontal cylinder in a similar process.

[0006] DE 197 38 513 C1 relates to a process for producing a metal foil consisting of plural metals where different electrolyte baths are used.

[0007] US 4,169,018 discloses a process for electroforming thin copper foil on aluminum carrier material for use in printed circuits wherein a continuous strip of aluminum material is prepared by etching and rinsing steps, whereupon the prepared carrier material is passed through a single preselected composition copper plating bath having nitrate ions in the concentration of between 3 and 30 grams/liter and fluoride ions in the concentration of between 0.05 and 10 grams/liter. This bath is operated at a constant, predetermined cathode current density of between about 5.5 and 33 A/dm^2 (50 and 300 A/foot^2).

[0008] US 5,236,572 which has been used to formulate the preamble part of patent claim 1 discloses a method for continuously manufacturing parts requiring precision micro-fabrication. A surface of a mandrel having a reusable pattern thereon is moved through an electroforming bath. While the mandrel surface moves through the bath, a metal layer is deposited on the mandrel surface to define a pattern. After the metal layer has been deposited to the selected thickness, the metal layer is separated from the mandrel surface.

[0009] GB 2243618 discloses also an electroforming mandrel making continuously electroformed thickness modulated or perforated metal foil.

[0010] It is the object of the invention to provide a continuous electroforming process of high productivity and flexibility which satisfies the economical and technical demands for the product. This object is solved by the process as defined in claim 1.

[0011] The aim of the invention is to achieve a high rate of formation and, thus, a more economical process, and moreover a more highly optimized product than that obtained by previous technology. Such an optimized product is obtained because the process provides a high degree of flexibility in producing electrodes of different design, different layered composite structure and different surface structure.

[0012] The process of claim 1 is characterized by moving said strip through at least one subsequent bath in which electrodeposition of metal takes place on both sides of said strip while it is moved through said subsequent bath, applying a current density of at least 10 A/dm^2 and up to 300 A/dm^2 to the conductive surface of the moving mandrel and to the metal surface of the strip in each of the subsequent baths; and directing a forced flow of electrolyte onto the surface of the layer and said strip, wherein the reusable conductive pattern of the surface of the mandrel takes the form of at least one battery electrode and the electrolyte contains additives suited specifically to permit combining a high rate of deposition with controlled surface roughness and controlled composition of the deposit.

[0013] Preferably, the current density is specified to induce a surface roughness in the range of R_a = 3 μm to R_a = 100 μm according to ISO 4287. Preferred current density ranges are from at least 20 A/dm^2 to 300 A/dm^2 and further preferred from at least 40 A/dm^2 to 300 A/dm^2.

[0014] In its simplest embodiment, only one subsequent bath is provided, however, it is possible to add further subsequent baths and to modify the electrolyte in each of said subsequent baths and the deposition conditions according to a desired layer structure to form multi-layer products. Hardening dispersoid particles can be added to the electrolyte in said first bath and/or in said subsequent baths. Further, alloying elements can be in-

cluded in the electrolyte of the subsequent baths to provide corrosion resistance and additional hardening to the layers formed therein.

[0015] The additives are selected from the polyaromatic/aliphatic class containing one or more oxo- and/or hydroxy- and/or keto-groups per molecule. The molecular mass of the additives may be in the range of about 300 to 1,000. The aliphatic chain should contain at least 4 to 8 C-atoms. It is preferred that the electrolyte contains a combination of at least two additive different substances with different molecular weight and polarity.

[0016] In the field of electrode position different types of additives, as referred to above, are applied such as dispersoid particles serving to harden the electrodeposited structure, further alloying elements serving to improve the corrosion resistance and/or hardness, and additives in a narrower sense which control the surface, microstructure and the incorporation of the other additives.

[0017] An essential feature of the invention is the provision of a forced flow of electrolyte onto the surface of the layer on the mandrel and the strip. The forced flow can be generated by forcing the electrolyte through a multitude of nozzles onto the surface of said mandrel or the layer on the mandrel, respectively, and onto the surface of the strip.

[0018] A specific mandrel should be used in the process of the invention which advantageously comprises the shape of a cylinder. A conductive pattern is provided on the surface of the mandrel which may consist of a conductive surface between parallel-sided isolating borders along the circumference of the cylinder. The conductive pattern may, alternatively, have the structure of an electrode, preferably a battery grid, similar to that described in DE 44 04 817 C1, or the structure of a current optimized grid design. It is further preferred to structure the conductive area of the surface of the mandrel also in the direction normal to the surface to form grooves, hillocks or the like which are transferred to the product during the forming process.

[0019] It is also preferred to use in the process of the invention anodes in any of the baths that consist of lead scrap or of remelted lead scrap. Thereby, refining of the lead is advantageously combined with the production of battery electrodes as an immediate combination of two process steps which normally would be performed separately. An inventive step is even seen in this novel combination.

[0020] The invention will now be further explained with reference to the drawing, where the single figure schematically shows an apparatus with which the continuous electroforming process of the invention can be carried out. The figure only shows the major parts of the apparatus. A mandrel 1 which is structured on its surface into a pattern of conductive and non-conductive areas, according to the design of the electrode shaped to be produced, is used as the cathode of an electrodeposition bath 2 with an anode 3. While the mandrel 1 is rotating, the metal deposite is forming and growing in thickness. After having reached sufficient resistance against tearing, corresponding to a specified thickness of the layer on the surface of mandrel 1, the layer is separated at a position 4 in strip shape 5 and is guided by guide and contact rolls 6 into the first subsequent bath 7 with anodes 8 and a submerged guide roll 9. Further subsequent baths such as 10, 11 essentially have the same parts.

[0021] The process permits to produce electrodes with low thickness, e. g. 50 to 500 μm, which are porefree and fully optimized in design and properties.

Example

[0022] To produce battery grids having a size of 15 cm x 15 cm and a grid area fraction of 50 % of the grid size, the surface of a cylinder serving as the mandrel having a diameter of 1 m and a length of 1.2 m is provided with conductive areas corresponding to the grid structure. The cylinder is submerged into an electrolyte as disclosed in DE 44 04 817 C1 and rotates with a circumferential velocity of 106.8 m/h. The electrodeposition occurs at the surface of the cylinder at a current density of about 80 A/dm^2. A lead grid strip forms on said cylinder and is separated therefrom upon reaching a layer thickness of 80 μm. Subsequently the strip is transferred to a second electrolyte bath having an effective length of 33 m and is brought to the desired final thickness of 0.5 mm by electrodeposition on both surfaces of the strip at a current density of 20 A/dm^2. The production rate is 95 grids per minute.

[0023] The features disclose in the foregoing description, in the claims and/or in the accompanying drawing may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A continuous electroforming process to form a strip for battery electrodes, comprising the steps of:

   - providing a mandrel (1) having on its surface a reusable pattern subdivided into conductive and non-conductive areas;
   - moving said mandrel (1) through an electroforming bath (2) to deposit a metal layer on said mandrel (1) while it moves through the electroforming bath until the metal layer has assumed the shape of the conductive pattern and a thickness at least sufficient to provide strength for the layer to be removed in strip form (5) from said mandrel (1); and
   - separating said layer from said mandrel (1)

   and wherein the electrolyte contains additives suited specifically to permit combining a high rate of depo-

sition with controlled surface roughness and controlled composition of the deposit;
characterised by

- moving said strip (5) through at least one subsequent bath (7) in which electrodeposition of metal takes place on both sides of said strip (5) while it is moved through said subsequent bath (7),
- applying a current density of at least 10 A/dm^2 and up to 300 A/dm^2 to the conductive surface of the moving mandrel (1) and to the metal surface of the strip (5) in each of the subsequent baths (7, 10, 11); and
- directing a forced flow of electrolyte onto the surface of the layer and said strip (5),

wherein the reusable conductive pattern of the surface of the mandrel (1) takes the form of at least one battery electrode.

2. A process according to claim 1, further **characterised by**

- applying a specified current density to induce a surface roughness in the range of Ra = 3 μm to Ra = 100 μm according to ISO 4287.

3. A process according to claim 1 or 2, **characterised by**

- modifying the electrolyte and the deposition conditions in each of said subsequent baths (7, 10, 11) according to a desired layer structure to form multilayer products.

4. A process according to any of claims 1 to 3, **characterised by** supplying hardening dispersoid particles to the electrolyte in said first bath (2).

5. A process according to any of claims 1 to 4, **characterised by**

- providing alloying elements in the electrolyte of said subsequent baths (7, 10, 11) to provide corrosion resistance to the layers formed therein.

6. A process according to any of claims 1 to 5, **characterised by**

- supplying hardening additives to the electrolyte in said subsequent baths (7, 10, 11).

7. A process according to any of the preceding claims, **characterised in that** additives are selected from the polyaromatic-aliphatic class containing one or more oxo- and/or hydroxy- and/or keto-groups per molecule.

8. A process according to any of the preceding claims, **characterised in that** the molecular mass of the additives is between 300 and 1000.

9. A process according to claim 7, **characterised in that** the aliphatic chain contains at least 4 to 8 C-atoms.

10. A process according to any of the preceding claims, **characterised in that** the electrolyte contains a combination of at least two different additives with different molecular weight and polarity.

11. A process according to any of the preceding claims, **characterised in that** the current density applied is in the range from at least 20 A/dm^2 to 300 A/dm^2.

12. A process according to any of the preceding claims, **characterised in that** the current density applied is in the range from at least 40 A/dm^2 to 300 A/dm^2.

13. A process according to any of the preceding claims, **characterised by**
directing the forced flow of the electrolyte by forcing it through a multitude of nozzles onto the surface of said mandrel (1).

14. A process according to any of the preceding claims, **characterised by**
directing the forced flow of the electrolyte by forcing it through a multitude of nozzles onto the surface of said strip (5).

15. A mandrel to be used in the process according to any of claims 1 to 13, having the shape of a cylinder and the surface of the mandrel (1) comprises a conductive pattern consisting of a conductive surface between parallel-sided isolating borders along the circumference of said cylinder.

16. A mandrel according to claim 15, **characterised in that** the conductive pattern on the surface of said mandrel (1) has the structure of an electrode, preferably a battery grid, or the structure of a current optimized electrode design.

17. A mandrel as claimed in any of claims 15 to 16, **characterised in that** the conductive area of the surface of said mandrel (1) is structured in the direction normal to the surface to form grooves, hillocks or the like which are transferred to the product during the forming process.

18. A process according to any of the preceding claims 1 to 14 in which any of the anodes (3, 8) in any of the baths consists of lead scrap.

19. A process according to any of the preceding claims 1 to 14 in which any of the anodes (3, 8) in any of the baths consists of remelted lead scrap.

Patentansprüche

1. Kontinuierliches galvanoplastisches Verfahren, um ein Band für Batterie-Elektroden herzustellen, das aus den folgenden Schritten besteht:

- Bereitstellung eines rotierenden Werkzeugs (1), das auf seiner Oberfläche eine wieder verwendbare Struktur aufweist, die in leitfähige und nicht-leitfähige Bereiche unterteilt ist;
- rotierende Bewegung des Werkzeugs (1) in einem galvanoplastisch wirkenden Bad (2), um eine Metallschicht auf dem genannten rotierenden Werkzeug (1) niederzuschlagen, während es sich in dem galvanoplastisch wirkenden Bad bewegt, bis die Metallschicht die Form der Struktur der leitfähigen Bereiche und mindestens eine Dicke angenommen hat, die ausreicht, um der Schicht die Festigkeit zu verleihen, die ausreicht, um die Schicht in Bandform (5) von dem genannten rotierenden Werkzeug (1) ablösen zu können; und
- Abtrennung der Schicht von dem genannten rotierenden Werkzeug (1)

und wobei der Elektrolyt Additive enthält, die spezifisch dazu geeignet sind, eine hohe Abscheidungsrate mit einer kontrollierten Oberflächenrauhigkeit und einer kontrollierten Zusammensetzung der niedergeschlagenen Schicht zu kombinieren;
dadurch gekennzeichnet, dass

- das genannte Band (5) durch mindestens ein nachfolgendes Bad (7) bewegt wird, in dem beidseitig galvanischer Niederschlag von Metall auf dem Band (5) stattfindet, während es durch das genannte nachfolgende Bad (7) bewegt wird,
- eine Stromdichte von mindestens 10 A/dm^2 und bis zu 300 A/dm^2 auf die leitfähige Oberfläche des bewegten rotierenden Werkzeugs (1) und auf die Metalloberfläche des Bandes (5) in jedem der nachfolgenden Bäder (7, 10, 11) angewendet wird; und
- ein erzwungener Strom von Elektrolyt auf die Schicht und auf das genannte Band (5) gerichtet wird,

wobei die wieder verwendbare leitfähige Struktur der Oberfläche des rotierenden Werkzeugs (1) aus der Form mindestens einer Batterie-Elektrode besteht.

2. Verfahren nach Anspruch 1, das weiterhin **dadurch gekennzeichnet ist,**

- **dass** eine spezifische Stromdichte angewendet wird, um eine Oberflächenrauhigkeit im Bereich von Ra = 3 μm bis Ra = 100 μm entsprechend ISO 4287 zu erzielen.

3. Verfahren gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet,**

- **dass** der Elektrolyt und die Niederschlagsbedingungen in jedem der genannten nachfolgenden Bäder (7, 10, 11) entsprechend einer gewünschten Schichtstruktur abgewandelt werden, so dass ein Multilagen-Produkt gebildet wird.

4. Verfahren gemäß einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** dem Elektrolyten in dem genannten ersten Bad (2) härtende Dispersoid-Teilchen zugesetzt werden.

5. Verfahren gemäß einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet,**

- **dass** dem Elektrolyten der genannten nachfolgenden Bäder (7, 10, 11) Legierungselemente zugesetzt werden, die den in ihnen gebildeten Schichten Korrosionsbeständigkeit verleihen.

6. Verfahren gemäß einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet,**

- **dass** den Elektrolyten in den nachfolgenden Bädern (7, 10, 11) härtende Zusätze zugesetzt werden.

7. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** Additive aus der aromatisch-aliphatischen Klasse ausgewählt werden, die eine oder mehrere Oxo- und/oder Hydroxy- und/oder Keto-Gruppen pro Molekül enthalten.

8. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Molekülmasse der Additive zwischen 300 und 1000 liegt.

9. Verfahren gemäß Anspruch 7, **dadurch gekennzeichnet, dass** die aliphatische Kette mindestens 4 bis 8 C-Atome enthält.

10. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Elektrolyt eine Kombination aus mindestens zwei Zusätzen mit unterschiedlicher Molekülmasse und unterschiedlicher Polarität enthält.

11. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die angewendete Stromdichte im Bereich von mindestens 20 A/dm^2 bis 300 A/dm^2 liegt.

12. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die angewendete Stromdichte im Bereich von mindestens 40 A/dm^2 bis 300 A/dm^2 liegt.

13. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der erzwungene Elektrolytstrom durch eine Vielzahl von Düsen auf die Oberfläche des genannten zylindrischen Werkzeugs (1) gerichtet wird.

14. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der erzwungene Elektrolytstrom durch eine Vielzahl von Düsen auf die Oberfläche des genannten Bandes (5) gerichtet wird.

15. Rotierendes Werkzeug, das in dem Verfahren entsprechend einem der Ansprüche 1 bis 13 verwendet wird, das die Form eines Zylinders hat, wobei die Oberfläche des rotierenden Werkzeugs (1) ein leitfähiges Muster aufweist, das aus einer leitfähigen Oberfläche zwischen zwei parallelen isolierenden Begrenzungen besteht, die entlang des Umfangs des genannten Zylinders verlaufen.

16. Rotierendes Werkzeug gemäß Anspruch 15, **dadurch gekennzeichnet, dass** das leitfähige Muster auf der Oberfläche des rotierenden Werkzeugs (1) die Struktur einer Elektrode, bevorzugt die eines Batteriegitters, aufweist oder die Struktur eines stromoptimierten Elektrodendesigns.

17. Rotierendes Werkzeug gemäß einem der Ansprüche 15 bis 16, **dadurch gekennzeichnet, dass** der leitfähige Bereich der Oberfläche des rotierenden Werkzeugs (1) in der Richtung normal zur Oberfläche Rillen, Erhebungen oder dergleichen aufweist, die während des Formgebungsvorgangs auf das Produkt übertragen werden.

18. Verfahren gemäß einem der vorhergehenden Ansprüche 1 bis 14, **dadurch gekennzeichnet, dass** jede beliebige Anode (3, 8) in jedem beliebigen Bad aus Bleischrott besteht.

19. Verfahren gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jede beliebige Anode (3, 8) in jedem beliebigen Bad aus umgeschmolzenem Bleischrott besteht.

Revendications

1. Procédé d'électroformage continu pour former une bande pour électrodes de batterie, comprenant les étapes consistant à :

- se procurer un mandrin (1) ayant sur sa surface un motif réutilisable subdivisé en zones conductrice et non conductrice ;
- déplacer ledit mandrin (1) à travers un bain d'électroformage (2) pour déposer une couche métallique sur ledit mandrin (1) pendant qu'il se déplace à travers le bain d'électroformage jusqu'à ce que la couche métallique ait adopté la forme du motif conducteur et atteint une épaisseur au moins suffisante pour apporter de la résistance afin que la couche soit retirée sous forme de bande (5) dudit mandrin (1) ; et
- séparer ladite couche dudit mandrin (1),

et dans lequel l'électrolyte contient des additifs spécifiquement adaptés pour permettre la combinaison d'une grande vitesse de dépôt avec une rugosité de surface contrôlée et une composition contrôlée du dépôt,
caractérisé par

- le déplacement de ladite bande (5) à travers au moins un bain consécutif (7) dans lequel un dépôt électrolytique de métal s'opère sur les deux côtés de ladite bande (5) pendant qu'elle est déplacée à travers ledit bain consécutif (7) ;
- l'application d'une densité de courant d'au moins 10 A/dm^2 et jusqu'à 300 A/dm^2 à la surface conductrice du mandrin mobile (1) et à la surface métallique de la bande (5) dans chacun des bains consécutifs (7, 10, 11) ; et
- la conduite d'un flux forcé d'électrolyte sur la surface de la couche et ladite bande (5),

dans lequel le motif conducteur réutilisable de la surface du mandrin (1) prend la forme d'au moins une électrode de batterie.

2. Procédé selon la revendication 1, **caractérisé en outre par**

- l'application d'une densité de courant spécifiée pour induire une rugosité de surface dans la gamme de Ra = 3 μm à Ra = 100 μm selon la norme ISO 4287.

3. Procédé selon la revendication 1 ou 2, **caractérisé par**

- la modification de l'électrolyte et des conditions de dépôt dans chacun desdits bains consécutifs (7, 10, 11) en fonction d'une structure de couche

souhaitée pour former des produits multicouches.

4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé par** l'adjonction de particules dispersoïdes de durcissement à l'électrolyte dans ledit premier bain (2).

5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé par**

- l'adjonction d'éléments d'alliage dans l'électrolyte desdits bains consécutifs (7, 10, 11) pour conférer une résistance à la corrosion aux couches qui y sont formées.

6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé par**

- l'adjonction d'additifs de durcissement à l'électrolyte dans lesdits bains consécutifs (7, 10, 11).

7. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les additifs sont choisis dans la classe des composés polyaromatiques-aliphatiques contenant un ou plusieurs groupes oxo et/ou hydroxyle et/ou céto par molécule.

8. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la masse moléculaire des additifs se situe entre 300 et 1000.

9. Procédé selon la revendication 7, **caractérisé en ce que** la chaîne aliphatique contient au moins 4 à 8 atomes de carbone.

10. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'électrolyte contient une combinaison d'au moins deux additifs différents avec un poids moléculaire différent et une polarité différente.

11. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la densité de courant appliquée se situe dans la gamme d'au moins 20 A/dm^2 à 300 A/dm^2.

12. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la densité de courant appliquée se situe dans la gamme d'au moins 40 A/dm^2 à 300 A/dm^2.

13. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par**

- la conduite du flux forcé de l'électrolyte en le forçant à travers une multitude de buses sur la surface dudit mandrin (1).

14. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par**

- la conduite du flux forcé de l'électrolyte en le forçant à travers une multitude de buses sur la surface de ladite bande (5).

15. Mandrin à utiliser dans le procédé selon l'une quelconque des revendications 1 à 13, ayant la forme d'un cylindre, et la surface du mandrin (1) comprenant un motif conducteur consistant en une surface conductrice entre des bords isolants à côtés parallèles le long de la circonférence dudit cylindre.

16. Mandrin selon la revendication 15, **caractérisé en ce que** le motif conducteur sur la surface dudit mandrin (1) a la structure d'une électrode, de préférence d'une grille d'accumulateur, ou la structure d'une conception d'électrode à courant optimisé.

17. Mandrin selon l'une quelconque des revendications 15 et 16, **caractérisé en ce que** la zone conductrice de la surface dudit mandrin (1) est structurée dans la direction perpendiculaire à la surface pour former des sillons, des buttes ou équivalents qui sont transférés au produit lors du procédé de formage.

18. Procédé selon l'une quelconque des revendications 1 à 14 dans lequel chacune des anodes (3,8) dans chacun des bains est constituée de déchets de plomb.

19. Procédé selon l'une quelconque des revendications 1 à 14 dans lequel chacune des anodes (3,8) dans chacun des bains est constituée de déchets de plomb refondus.

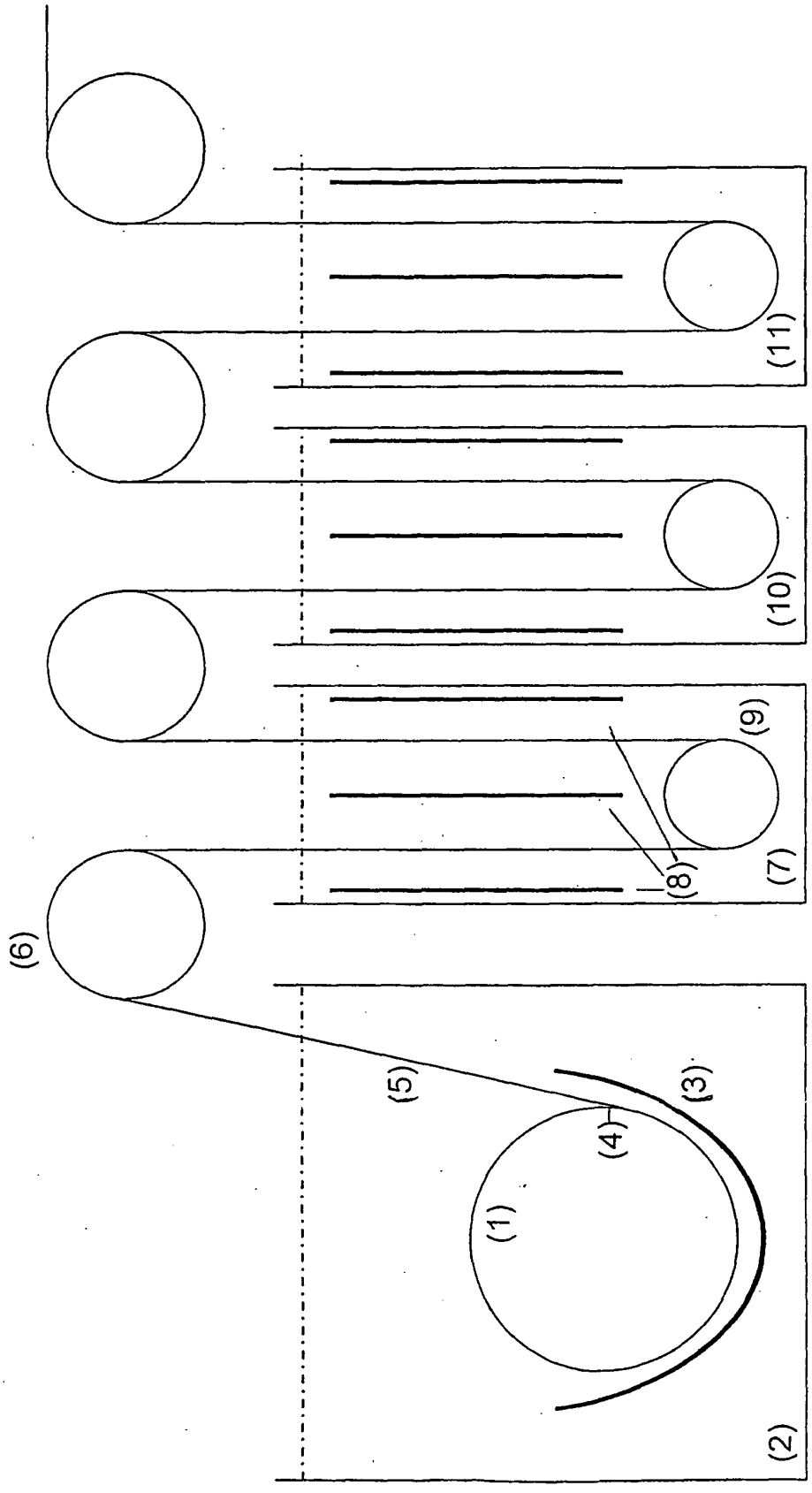


Fig. 1

REFERENCES CITED IN THE DESCRIPTION

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